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Abstract. The ITWG continues to expand as a community of active practitioners of nuclear forensics. This informal, multi-lateral group is a successful model for international cooperation through its ability to share analytical techniques, data, and insights relevant to the security of the global nuclear fuel cycle. The work of the ITWG is done is its task groups. Through strengths in nuclear forensic science and the ability to draw on international experience, the ITWG plays an important role in the pursuit of crucial global counter-terrorism and nonproliferation objectives.

1. Introduction

The availability of nuclear technology is critical to the world's energy and security needs. To meet these demands, nuclear materials and related technical capabilities are transferred to global markets to ensure independent supply. A requirement is that material does not get diverted for unauthorized purposes. Capabilities for the protection and control of metric tons of legacy Cold War nuclear and radioactive material (including high-enriched uranium and plutonium) are also required to eliminate the proliferation and terrorist vulnerabilities associated with these residuals.

Nuclear forensics is a scientific discipline that utilizes the isotopic, chemical, and physical analyses of nuclear and radiological materials to elucidate signatures indicative of the origin and history of these materials. Since its creation in 1995, the Nuclear Smuggling International Technical Working Group (ITWG) has advanced this discipline and its application to protect against nuclear and radioactive threats including illicit trafficking and unauthorized diversion. A recent paper described the creation of the ITWG, its terms of reference, organization, and recent activities including a model action plan to guide nuclear forensic investigations [1]. Through its focus on nuclear forensic best practice, the ITWG has gained international

recognition as a community of nuclear security and law enforcement experts working cooperatively to advance the science of nuclear forensics [2].

Since its inception, the ITWG has informally reported to the G8's Nuclear Safety and Security Group. The G8 recommends that the ITWG remain an apolitical organization. As a technical working group, any one nation or international organization does not sanction the ITWG, and this arrangement has allowed for dynamic multi-national engagement. Due to its creation as a technical working group, the ITWG is distinct from other international security organizations. The ITWG draws its strength from the scientists, law enforcement officials, emergency responders, nuclear regulators, and security experts that have participated in its annual meetings and task groups. Each meeting provides a forum for current reports from states and international organizations with a commitment to technical nuclear forensics as a capability to respond and deter nuclear proliferation and terrorism concerns. Technical discussion allows for peer-review of the science as well as rapid dissemination of key findings and recommendations. The result is an international community of experts well versed in the application of nuclear forensics. For these reasons, the ITWG is effective at equipping governments and partner organizations with guidance and technical solutions in nuclear forensics used to address national requirements to ensure the safety and security of nuclear and radioactive materials.

The ITWG focuses on development and application of nuclear forensics to ensure the security of nuclear and radioactive materials from unauthorized possession and diversion. A guiding principal of the group has been that reliable nuclear forensics conclusions can only be obtained if the entire process from sample collection at the incident site to the analysis and data interpretation in the laboratory is controlled and technically rigorous. A key component of a comprehensive response includes the consideration of nuclear forensic requirements at the incident site (or crime scene). For this reason, the ITWG drafted a model action plan specifying recommendations for incident response including initial categorization of the suspect material, collection of forensic evidence, distribution and analysis of evidence by a nuclear forensic laboratory, and case development including interpretation of forensic signatures. The International Atomic Energy Agency subsequently published this plan [3]. Since its publication key elements have been adopted by states in formulating their own nuclear forensic response to illicit trafficking.

Task Groups conduct the work of the ITWG. The task groups are standing committees of experts each chaired by a task group leader. An Executive Committee oversees the task group, sets technical priorities and reviews task group findings before dissemination to interested outside parties. The purpose of the present report is to detail recent technical accomplishments of the ITWG and its task groups.

2. Findings from annual meetings

International interest in the ITWG annual meeting continues to grow. The G8 Nuclear Safety and Security Group has encouraged the ITWG to expand its

membership to interested states in the context of its strength as a scientific working group. The 13th annual meeting in Sofia, Bulgaria in 2008 was the largest ITWG meeting to-date and drew more than 77 participants. Reports and findings from recent meetings include:

- Member states are developing and utilizing their own national capabilities to pursue nuclear forensic investigations of uranium ore, uranium ore concentrate, uranium tetra-fluoride, low enriched uranium nuclear fuel, highly enriched uranium nuclear fuel, and plutonium. Important is the ability to understand forensic signatures associated with each stage of the nuclear fuel cycle. Studies involve analysis and interpretation of isotope systematics, chemical and molecular form, and physical properties (e.g., color, density, grain size, sorting, shape).

- Law enforcement is partnering with nuclear forensic scientists to build specialized infrastructure and develop techniques for the collection of conventional forensic evidence (e.g., hair, fiber, fingerprints, tool marks, dust, pollen, explosive residues) from contaminated substrates as well as study the degradation of evidence in the presence of high level radiation fields (10 to 1000 kGy). Forensic examiners are also trained to collect evidence in contaminated environments with all necessary radiological protections and in accordance with prescribed methods.

- Nuclear forensics is a critical component of national response plans for incidents of illicit trafficking. The International Atomic Energy Agency, through its Illicit Trafficking Data Base, continues to report unauthorized possession and criminal activity typically involving small amounts of nuclear and radiological materials. As material is interdicted, nuclear forensics is applied to protect the safety of the public and incident responders, to determine the type and level of radioactivity, and to link the materials with perpetrators, sources, and paths of diversion. Nuclear forensics has also been incorporated in several national-level exercises involving response to simulated incidents involving weapons of mass destruction.

- Participation from new member states provides insights into the emerging threats posed by illicit nuclear trafficking as well as the requirements for nuclear forensics response. Development of technical nuclear forensics capabilities must be in concert with appropriate legal instruments to ensure that the unauthorized possession or use of nuclear and radiological materials is investigated by law enforcement officials and prosecuted if national laws are broken. In the past years, experts from Afghanistan, Singapore, South Africa, and the Republic of Korea have attended the ITWG annual meeting for the first time to learn about international nuclear forensic best practice as well as to augment the general experience of the working group.

3. Recent work undertaken by the ITWG

The technical work of the ITWG reflects the need of member states to utilize nuclear forensics in their own response to acts of nuclear smuggling or the unauthorized possession of nuclear or radioactive materials. Recent work includes recommendations for collection and preservation of nuclear forensic evidence, development of consensus guidelines for nuclear forensics analysis and interpretation, presentations and publications at international nuclear security meetings, and conduct of scenario-based and analytic exercises. As noted previously the ITWG's standing task groups administer these activities.

3.1 Evidence Collection Task Group (formerly the First Responder Task Group)

Since its inception, the ITWG has relied on a close association with the international law enforcement community to collect and analyze evidence associated with the illegal possession or trafficking of nuclear and radiological materials. While law enforcement investigators are well versed with collecting and preserving conventional forensics evidence, nuclear forensics provides unique challenges due to the potential hazards associated with handling radioactive unknowns as well as the specialized laboratories and techniques required to collect and analyze contaminated conventional as well as radioactive evidence. For this reason, the ITWG has formed an evidence collection task group to provide expert advice to those charged with collecting evidence of this kind.

The evidence collection task group currently seeks to develop a nuclear forensic exercise catalogue in order to share experience and lessons learned from past exercises. The group is finalizing a template to be distributed to member states that catalogues national response exercises involving samples collected for nuclear forensic analysis. Data will be captured electronically, reviewed by task group leaders, and uploaded to the existing ITWG web-site.

The evidence collection task group is also developing a draft best practice document for response to crime scenes involving radioactive materials or contamination. Included are considerations for general safety, contamination control, sampling of evidence, initiation of chain of custody, documentation, and transportation of radioactive evidence to a nuclear forensic laboratory. This draft will solicit and incorporate existing guidance of those states that already implement their own national response plan in this area. Once approved by the evidence collection task group, the final version will be passed to the guidelines task group for their review and acceptance.

3.2 Guidelines Task Group

The ITWG recognized that consensus guidelines allow laboratories to develop or improve their nuclear forensic capabilities, enable inter-comparison of results among all of the ITWG laboratories, and ensure analytical results that can be used in the

potential criminal prosecution of illicit trafficking cases in a court of law. The guidelines provide a generalized approach to techniques that advance best practice, but are not meant to be prescriptive laboratory procedures. Recently, the list of draft guidelines was expanded to include not just analytical methods but also recommendations for nuclear forensic response and interpretation.

Draft guidelines currently being proposed by the task group include i) a graded nuclear forensic evaluation framework that allows rigorous comparison of data, ii) a framework for crime scene response that enables pre-planned cooperation between law enforcement and radiation protection personnel, iii) methods for radiochemical separations, iv) techniques for gamma spectrometry measurements, v) techniques for thermal ionization mass spectrometry measurements, vi) methods for analytical sampling, and vii) a classification and taxonomy scheme for nuclear materials. Once guidelines have been reviewed by the ITWG Executive Committee, they are considered approved and will be posted on the ITWG web-site or may be published, on approval, in a broader forum.

Besides drafting the guidelines, the task group has also established a procedure for approving these guidelines through independent review. Included in this approval step is the ability to revise and update these guidelines as new procedures, knowledge, or experience becomes available.

3.3 Exercise Task Group

Analytical and scenario-based exercises have been an essential activity of the ITWG since its inception. Exercises provide an opportunity for laboratories to assess their performance on analysis of contaminated evidence as well as to demonstrate declared capabilities. The exercises are designed as a means to learn through shared experience analyzing a common sample and are not designed to test or grade an individual laboratory or an affiliated national response plan. The ITWG conducted analytical exercises involving plutonium oxide in 1998 – 2000 and highly-enriched uranium oxide in 2000 – 2002. As reported previously, in these round-robins, a representative nuclear sample was prepared, aliquoted, and shipped to participating national laboratories, and analyzed for major and minor isotopes, fission and activation products, major, and trace elements, and physical characteristics [4]. In the first round-robin involving plutonium, six laboratories participated in the exercise; in the second exercise involving HEU, ten laboratories participated. A third analytical exercise is being planned for later in 2009 with nine international laboratories scheduled to participate. The conduct of this exercise is expected to be similar to the first two. The exercises are comprise two distinct phases. The first phase consists of the collection of analytical data and interpretation of results by the participating laboratory; the second phase allows all laboratory participants to discuss and prioritize the utility of techniques and methods applied to the round-robin analysis.

An additional priority for the exercise task group has been to develop a plan for future exercise materials. The group bases its selection on analyte (i.e., isotope of interest),

matrix (i.e., oxide, metal, pellet, ore), and ancillary characteristics (i.e, packaging materials, conventional forensic evidence – fibers, hair fingerprints) that are representative of a real sample that might potentially be interdicted. In addition to special nuclear materials, potential future analytical exercises might target low-enriched uranium fuel pellets and uranium oxide, radiologically contaminated evidence, and fission products (e.g., ^{137}Cs or ^{90}Sr). In concert with the identification of materials, exercises must drive the development of laboratory analytical protocols and nuclear forensic laboratory capabilities. Focused work-shops and table-top exercises are further identified by the task group as an effective means to promote nuclear forensics best practice.

3.4 Communication and Outreach Task Group

Regular communication of recent technical advances in nuclear forensics analysis and interpretation as well as recommendations for the best application of nuclear forensics is essential for the continuing success of the working group. The ITWG has two distinct audiences for its work. The first are local experts in nuclear science and law enforcement who will benefit from improvements to detect interdicted material and subsequently categorize and characterize this material as part of investigation regarding loss of control. Topics here include improved methods of analysis, signature discovery, and knowledge management and analysis. The second are policymakers, governmental officials, and organizational representatives at the national and international level who require an orientation to nuclear forensics capabilities to devise response plans that address nuclear proliferation and terrorism. In this vein, the science of nuclear forensics can serve as the foundation for a dialogue between nations that can lead to bi-lateral and multi-lateral security partnerships [5].

Due to the transboundary nature of illicit trafficking, cooperation between affected states is paramount to providing insights to the sources and routes of nuclear and radiological material that is diverted from authorized control. Furthermore knowledge of the international nuclear fuel cycle and the persistence of isotopic, chemical, and physical signatures associated with each stage enables nuclear forensics interpretation and requires outreach to access relevant data, samples, and subject matter expertise.

The ITWG has been identified as an example of successful multi-lateral assistance in nuclear forensics [2, 3, 6]. Because of the ITWG's unaffiliated and informal stature, bi-lateral cooperation to provide nuclear forensics assistance is often initiated after initial contacts are made at the ITWG annual meetings. This success is predicated on the information maintained on a secure ITWG web-site as well as regular presentations at international nuclear security workshops, symposia, and conferences. Specifically over the past several years, the ITWG has presented at leading international security meetings hosted by the Federal Bureau of Investigation, the Royal Society, and the American Association for the Advancement of Science.

Close cooperation between the ITWG and the Office of Nuclear Security of the International Atomic Energy Agency is underway. The IAEA will co-host the next ITWG annual meeting (ITWG-14) in late June 2009 in Vienna. Further legal instruments for security cooperation include the Global Initiative to Combat Nuclear Terrorism. The objectives of this international agreement are to collect and integrate global expertise in nuclear nonproliferation and counter terrorism and are consistent with the involvement of the ITWG.

4. The future of the ITWG

The changing nuclear security environment and the increased international participation at its recent annual meetings requires the ITWG to address its terms of reference (charter). The ITWG is presently drafting a terms of reference that will provide written guidelines that govern its organization and conduct. These terms specify the ITWG's objectives, areas of interest, organization of the Executive Committee and Task Groups, membership requirements, rights, and responsibilities, as well as administration of ITWG annual meetings. The terms of reference will help the entire membership to understand and accept the organizational structure of the working group. These terms will be presented to the membership for their review as part of the upcoming ITWG annual meeting.

The ITWG also recognizes the importance of training to establish or improve nuclear forensics best practice among atomic energy experts and law enforcement officials. The ITWG is exploring partnerships with other international nuclear security organizations to review or augment an effective nuclear forensic training curriculum that incorporates all recent technical advances to stimulate effective response.

Libraries and data banks of nuclear or radiological materials have been proposed as a vital mechanism to facilitate interpretation and appropriate response in the aftermath of a significant interdiction or attack involving these materials [7]. The ITWG has already successfully promoted exchanges of nuclear forensics data between states through its analytic round-robins as well as other collaborations. The ITWG is poised to contribute to the structure and population of priority nuclear forensic data banks in the future.

After more than a decade, the ITWG continues to expand as a community of active practitioners of nuclear forensics. This informal, multi-lateral group is a successful model for international cooperation through its ability to share analytical techniques, data, and insights relevant to the security of the global nuclear fuel cycle. Through strengths in nuclear forensic science and the ability to draw on international experience, the ITWG plays an important role in the pursuit of crucial global counter-terrorism and nonproliferation objectives.

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